# Zoo Beach, Racine, Wisconsin

Located near the Racine Zoo and lakefront park, Zoo Beach (Figure 1) is a smaller and quieter neighbor to the popular North Beach, which lies just to the south. Like North Beach, Zoo Beach is maintained by Racine's Parks, Recreation, and Cultural Services Department, which is responsible for regular beach grooming and lifeguard services throughout the summer. Based on daily counts by lifeguards in 2010 and 2011, total annual visits to Zoo Beach are estimated at between 3,700 and 4,700.

**Figure 1.** *Zoo Beach, Racine, Wisconsin.*

Responsibility for monitoring water quality falls with the Racine Health Department, which sends monitoring personnel to collect samples five days per week (Monday through Friday) at three fixed stations along 1,180 ft of shoreline. Because they are located next to one another along the same stretch of shoreline, North and Zoo beaches are monitored one after the other by the same personnel, with all of the samples transported to the health department lab for testing. Tests include both the standard 18-hour, colilert analysis and a 2-hour, quantitative polymerase chain reaction (qPCR) analysis. Individual samples are composited before being tested.

In 2004, Zoo Beach was posted with 13 swim advisories and four beach closures. By 2010, advisories had been reduced to four, with no closures. In 2011, there were five advisories. Like neighboring North Beach, Zoo Beach has been the subject of long-term sanitary surveys, including intensive water-quality

monitoring at multiple locations and concurrent measurements of nearshore, onshore, and hydro-meteorological conditions. This monitoring has informed several best management practices and beach improvements, including the redesign of the English Street outfall, effectively the boundary between Zoo and North beaches. During most rainfall events, stormwater flowing into the redesigned system passes through two "vorceptors" (which settle debris and particulates) and is then routed through a series of wetland cells before discharging at Zoo Beach (Figure 1). The higher number of advisories at Zoo Beach relative to North Beach may be related to the location of the wetland outlet, which has a low flow on most days and larger flows during rainfall events. In contrast, the southern bypass outlet (at the site of the original outfall) only discharges to the lake during heavy rainfall events.

## *Nowcast Models*

The 2012 beach season was the first with an operational nowcast at Zoo Beach. Although Wisconsin DNR staff conducted the data assembly, formatting, and model set-up, Racine Health Department staff built the model from a shared *Virtual Beach* project (.VBPX) file. The full process of data assembly, model set-up, and model-building is described in detail in the report *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches*[1].

The 2012 Zoo Beach nowcast model was specified as:

LOG10(*Ecoli*) = 0.2516 + 0.3805*(SQUAREROOT(*Wave_Height_ft*)) -
0.676*(QUADROOT(*RRAIN1*)) + 0.3209*(POWER(*RRAIN6*,0.3333333)) +
0.09746*(SQUAREROOT(*RRAIN48*)) + 0.3751*(POWER(*CLDCV*,0.3333333)) -
6.203*(INVERSE(*ATEMP*,3.28725)) + 0.06553*(QUADROOT(*Qmax672*)) +
0.3889*(POLY(*CurrentA_comp*(CSPD,CDIR,-5.41),1.1815802,-0.21025639,12.837678)) +
0.003368*(SQUARE(*WindO_comp*(WSPD,WDIR,-5.41)))

Where:

*Ecoli* = *E. coli* (MPN/ 100mL) — Measured by the Racine Health Dept.
*ATEMP* = Air Temperature (degrees C) — GLCFS, NOAA
*CurrentA_comp* = Alongshore Current (meters/sec) — Derived from:
Surface Current Velocity (meters/sec) — GLCFS, NOAA
Surface Current Direction (toward 0-360 deg.) — GLCFS, NOAA
*CLDCV* = Cloud Cover (percent) — GLCFS, NOAA
*Qmax672* = Root River Discharge, 28-day max ($ft^3$/sec) — USGS Gage
*RRAIN1* = Rainfall, 1 hour (mm) — Radar Est. from the North Central River Forecasting Center, NOAA
*RRAIN6* = Rainfall, 6 hours (mm) — Radar Estimate… NOAA
*RRAIN48* = Rainfall, 48 hours (mm) — Radar Estimate…. NOAA
*WaveHeight_ft* = Wave Height (ft.) — Estimated by the Racine Health Dept.
*WindO_comp* = Onshore Wind (meters/sec) — Derived from:
Wind Velocity (meters/sec) — GLCFS, NOAA
Wind Direction (from 0-360 deg.) — GLCFS, NOAA

[1] Mednick, A.C. 2012. *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches.* PUB-SS-1098. Bureau of Science Services, Wisconsin Department of Natural Resources, Madison.

And where:

LOG10 = logarithm, base 10
INVERSE = $1/X$
POLY = polynomial transformation ($a + bX + cX^2$)
POWER = $X^{1/3}$
PROD = $X1 * X2$
QUADROOT = $X^{1/4}$
SQUARE = $X^2$
SQUAREROOT = $X^{1/2}$

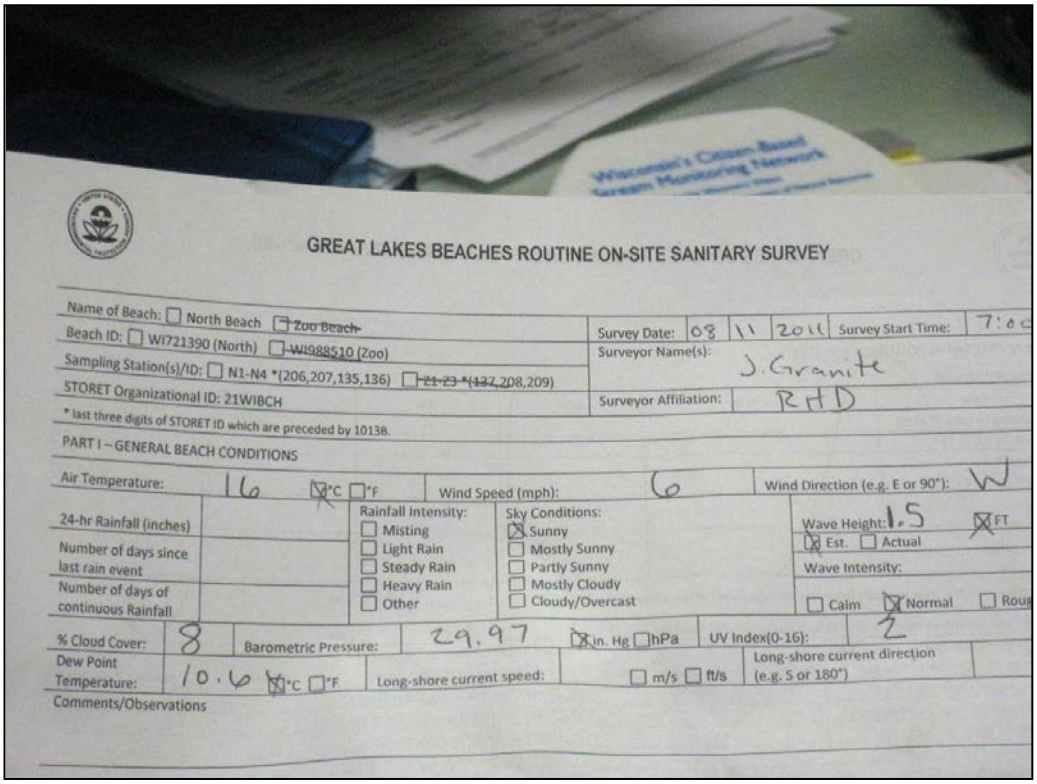
## *Nowcast Model Operation*

Racine Health Department staff members operate the Zoo Beach nowcast. The process of running the nowcast generally takes the operator five minutes or less per day, on top of routine beach monitoring and public notification activities. Nowcast model runs are conducted after monitoring personnel return to the health department lab from collecting water samples and taking routine sanitary survey measurements at the beach. Beach monitoring generally takes place around 07:00 a.m., in order to allow time for samples to be returned to the lab, prepped for qPCR analysis, and run through the 2-hour process before posting an advisory (if deemed necessary based on the results) by mid-morning. In some cases the nowcast operator will have conducted the field work. On most days, however, other staff members conduct the field work and provide the nowcast operator with the needed input values recorded on standardized paper forms (Figure 2).

The procedure for running the Zoo Beach nowcast was for the operator to first access and download "automated" data inputs via the U.S. Geological Survey's *Environmental Data Discovery and Transformation* (ENDDAT) system [2] using a custom ENDDAT web URL developed by Wisconsin DNR staff. Launching the URL downloads a one-row table of the most recent values of several model inputs including: *CLDCV* (percent cloud cover), *Qmax672* (28-day maximum Root River discharge, $ft^3$/sec), *RRAIN1*, *RRAIN6*, and *RRAIN47* (millimeters of rain estimated by radar over the past 1, 6, and 48 hours), *Significant Wave Height* (meters) and *Direction* (0-360 degrees), and *Surface Current Velocity* (meters/sec) and *Direction* (0-360 degrees). Next, the operator opened the *Virtual Beach* model (.VBMX) file and imported the daily ENDDAT table into the MLR Prediction tab, leaving the operator to manually-enter a single value: *WaveHeight_ft* (estimated wave height in feet). Once all of the input values were entered, the operator executed the model to make a prediction (Figure 3).

Outputs of the nowcast included the estimated concentration of *E. coli*, as well as the statistical probability of exceeding the 235 CFU/100 mL water-quality standard. Health department staff used these outputs together with qPCR and sanitary survey results as multiple lines of evidence for determining whether or not to post a water-quality advisory or close the beach. The nowcast was generally conducted while qPCR analysis was in progress. Whereas the process of conducting the nowcast takes five minutes or so, the process of conducting qPCR typically takes two hours, including sample preparation, system operation, and output interpretation (Figure 4). As they are completed, nowcast predictions, 18-hour lab results, and qPCR are displayed alongside one another for daily comparison and validation.

[2] http://cida.usgs.gov/enddat/



GREAT LAKES BEACHES ROUTINE ON-SITE SANITARY SURVEY

Name of Beach: ☐ North Beach ☐ ~~Zoo Beach~~
Beach ID: ☐ WI721390 (North) ☐ ~~WI988510 (Zoo)~~
Sampling Station(s)/ID: ☐ N1-N4 *(206,207,135,136) ☐ ~~21-23 *(137,208,209)~~
STORET Organizational ID: 21WIBCH
* last three digits of STORET ID which are preceded by 10138.

Survey Date: 08 | 11 | 2011 Survey Start Time: 7:0
Surveyor Name(s): J. Granite
Surveyor Affiliation: RHD

PART I – GENERAL BEACH CONDITIONS

Air Temperature: 16 ☒°C ☐°F
Wind Speed (mph): 6
Wind Direction (e.g. E or 90°): W
24-hr Rainfall (inches)
Number of days since last rain event
Number of days of continuous Rainfall
Rainfall Intensity: ☐ Misting ☐ Light Rain ☐ Steady Rain ☐ Heavy Rain ☐ Other
Sky Conditions: ☒ Sunny ☐ Mostly Sunny ☐ Partly Sunny ☐ Mostly Cloudy ☐ Cloudy/Overcast
Wave Height: 1.5 ☒FT ☒ Est. ☐ Actual
Wave Intensity: ☐ Calm ☒ Normal ☐ Rou
% Cloud Cover: 8
Barometric Pressure: 29.97 ☒in. Hg ☐hPa
UV Index(0-16): 2
Dew Point Temperature: 10.6 ☒°C ☐°F
Long-shore current speed: ☐ m/s ☐ ft/s
Long-shore current direction (e.g. S or 180°)
Comments/Observations

**Figure 2.** *Routine sanitary survey form for Zoo Beach, Racine.*

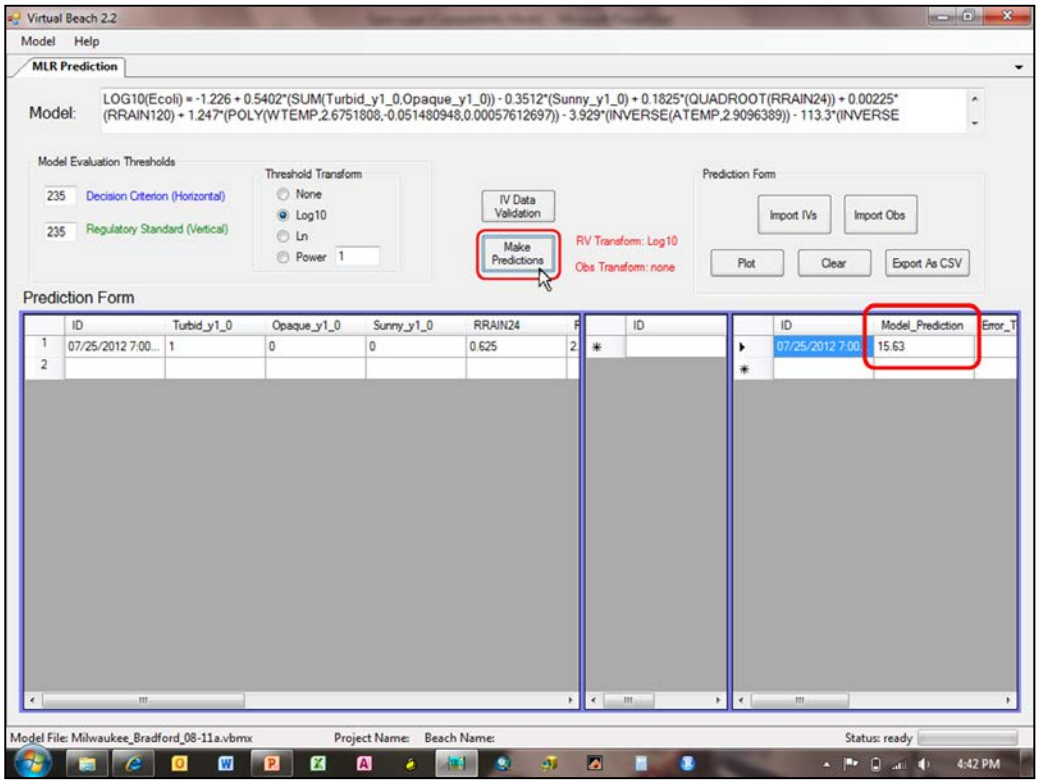



**Figure 3.** *Virtual Beach's "MLR Prediction" tab.*

**Figure 4.** *Conducting qPCR analysis. clockwise from top left: sample preparation (A-B), setting-up a qPCR run (C), and displayed results (D).*

## *Nowcast Results*

The 2012 Zoo Beach nowcast was operated from June 28 through August 31. That season, for the first time, the Racine Health Department was granted permission by the U.S. EPA to use qPCR results for regulatory purposes; i.e., posting swim advisories or issuing beach closures. The 2012 nowcast was operated simultaneous with qPCR. Rather than using nowcast-predicted concentrations of *E. coli* as the basis for posting advisories, the health department used model-estimated exceedance probabilities in conjunction with qPCR results – and in some cases, field-observed beach conditions such as strong onshore winds following rainfall – as multiple lines of evidence for posting advisories. On one occasion, the nowcast exceedance probability indicated that qPCR results were incorrectly in exceedance of the 1,000 CFU/100 mL beach closure guideline. This was confirmed by secondary qPCR analysis and the following day's 18-hour lab results. This combined approach resulted in the posting two swim advisories and one closure that would have otherwise been missed, 1 avoided advisory that otherwise would have been posted, and 1 avoided closure.

# *Beach Water-quality Nowcast Model Case Study*

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